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Greater Sedentary Hours and Slower Walking Speed Outside the Home Predict Faster Declines in Functioning and Adverse Calf Muscle Changes in Peripheral Arterial Disease

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Objectives In participants with peripheral arterial disease (PAD), we determined whether more sedentary behavior and slower outdoor walking speed were associated with faster functional decline and more adverse changes in calf muscle characteristics over time.

Background Modifiable behaviors associated with faster functional decline in lower-extremity PAD are understudied.

Methods Participants were 384 men and women with an ankle brachial index <0.90 followed for a median of 47 months. At baseline, participants reported the number of hours they spent sitting per day and their walking speeds outside their homes. Participants underwent baseline and annual measures of objective functional performance. Calf muscle characteristics were measured with computed tomography at baseline and every 2 years subsequently. Analyses were adjusted for age, sex, race, comorbidities, ankle brachial index, and other confounders.

Results Slower walking speed outside the home was associated with faster annual decline in calf muscle density (brisk/striding pace -0.32 g/cm^3, average pace -0.46 g/cm^3, casual strolling -1.03 g/cm^3, no walking at all -1.43 g/cm^3, p trend <0.001). Greater hours sitting per day were associated with faster decline in 6-min walk (<4 h: −35.8 feet/year; 4 to <7 h: −41.1 feet/year; 8 to <11 h: −68.7 feet; ≥12 h: −78.0 feet; p trend = 0.008). Similar associations were observed for greater hours sitting per day and faster declines in fast-paced (p trend = 0.018) and usual-paced (p trend < 0.001) 4-m walking velocity.

Conclusions Greater sedentary hours per day and slower outdoor walking speed are modifiable behaviors that are associated with faster functional decline and greater decline in calf muscle density, respectively, in patients with PAD. (J Am Coll Cardiol 2011;57:2356–64) © 2011 by the American College of Cardiology Foundation

Men and women with lower-extremity peripheral arterial disease (PAD) have greater functional impairment and faster functional decline compared with those without PAD (1–3). Few therapies have been identified that improve functional performance in men and women with PAD. Although supervised treadmill exercise improves treadmill walking endurance in patients with PAD (4), medical insurance does not typically cover supervised treadmill exercise and few patients with PAD participate (5).

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Few data are available regarding associations of modifiable lifestyle behaviors with functional decline and other important outcomes in people with PAD. Therefore, in a prospective, observational study, we assessed associations of the number of sedentary hours per day with rates of functional decline and changes in calf muscle characteristics among men and women with PAD. We also studied associations of outdoor walking speed with functional decline and changes in calf muscle characteristics among participants with PAD. We hypothesized that more seden-

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tary hours per day and slower walking speed outside the home would be associated with faster functional decline and more adverse calf muscle changes over time among men and women with PAD.

Methods

Study overview. The institutional review boards of Northwestern University and Catholic Health Partners Hospital approved the protocol. Participants gave written informed consent. Participants were enrolled in the WALCS (Walking and Leg Circulation Study) II cohort, a prospective, observational study designed to identify mechanisms of functional decline in PAD (6,7). Participants underwent baseline measures and returned annually for up to 4 follow-up visits.

Participant identification. Recruitment, participation rates, and exclusion criteria for the WALCS II cohort have been described (6,7) and are summarized briefly here. Participants were age 59 years and older and were identified from among consecutive patients diagnosed with PAD in Chicago-area noninvasive vascular laboratories (5,6). A small number of participants with PAD were identified from among consecutive patients in a large general internal medicine practice at Northwestern University. PAD was defined as ankle brachial index (ABI) <0.90 (6,7). Patients with dementia were excluded because of their inability to answer questions accurately. Nursing home residents, wheelchair-bound patients, and patients with foot or leg amputations were excluded because they had severely impaired functioning at baseline. Non–English-speaking patients were excluded because investigators were not fluent in non-English languages. Patients with recent major surgery were excluded.

ABI measurement. A handheld Doppler probe (Nicolet Vascular Pocket Dop II, Nicolet Biomedical Inc, Golden, Colorado) was used to measure systolic pressures in the right and left brachial, dorsalis pedis, and posterior tibial arteries (6–8). Each pressure was measured twice. For each leg, the ABI was calculated by dividing the mean of the dorsalis pedis and posterior tibial pressures by the mean of the 4 brachial pressures (8). Zero values for the dorsalis pedis and posterior tibial pulses were set to missing for the ABI calculation. Average brachial pressures in the arm with the highest pressure were used when 1 brachial pressure was higher than the opposite brachial pressure in both measurement sets and the 2 brachial pressures differed by 10 mm Hg or more in at least 1 measurement set. In these cases, subclavian stenosis was possible (9). The leg with the lowest ABI was used in analyses.

Measures of sedentary hours per day and participant-reported walking speed outside the home. At baseline, participants were asked, "In a typical day, how many hours do you spend sitting? Be sure to include time spent sitting at a desk, riding in a car, eating, and sitting up watching television" (10,11). Participants were also asked, "In a typical day, how many hours do you spend lying down? Include time spent sleeping, lying down resting, napping, and trying to get to sleep" (10). Based on responses to these questions, we calculated: 1) the number of hours spent sitting per day; and 2) the total number of sedentary hours per day (including hours spent sitting and lying down). At baseline, participants were asked to describe their typical walking speed when walking outside their house. Specifically, participants were asked, "When you walk outside your house, what is your usual walking speed?" (10). Participants selected from one of the following responses: 1) no walking at all; 2) casual strolling (0 to 2 miles/h); 3) average or normal (2 to 3 miles/h); and 4) brisk or striding (>3 miles/h).

Abbreviations and Acronyms

ABI = ankle brachial index

BMI = body mass index

CT = computed tomography

PAD = peripheral arterial disease

Functional outcomes. Functional outcomes were assessed at baseline and annually and consisted of average annual declines in 6-min walk performance, usual-paced 4-m walking velocity, and fastest-paced 4-m walking velocity.

6-MIN WALK. The 6-min walk test is a validated and reliable measure of walking performance that predicts mortality, mobility loss, and correlates significantly with physical activity levels during daily life (12–15). Following a standardized protocol (12–15), participants walk up and down a 100-foot hallway for 6 min after instructions to cover as much distance as possible.

4-M WALKING VELOCITY. Walking velocity was measured with a 4-m walk performed at "usual" and "fastest" paces, based on a previous study (14–16). Each walk was performed twice. The faster walk in each pair was used in analyses (14–16).

Calf muscle characteristics. Calf muscle measurements were assessed with computed tomography (CT) at baseline and at the 2- and 4-year follow-up visits using a CT scanner (LightSpeed, General Electric Medical Systems, Waukesha, Wisconsin) (6,7). Cross-sectional (2.5 mm) images of the calves were obtained at 66.7% of the distance from the distal to the proximal tibia (6,7). Cross-sectional images were analyzed using BonAlyse (BonAlyse Oy, Jyvaskyla, Finland), a software for processing CT images that identifies muscle tissue, fat, and bone (6,7,17). The muscle outline was traced manually, excluding subcutaneous fat and bone. When quantifying muscle area, the BonAlyse software quantifies voxels within a range corresponding to muscle density (9 to 271 mg/cm^3) and excludes voxels corresponding to fat density (−270 to 8 mg/cm^3) (6,7). Intramuscular fat is quantified by summing voxels corresponding to fat within muscle tissue. Muscle density measures the quantity of muscle per volume within the voxel range corresponding to muscle (9 to 271 mg/cm^3) and is a measure of muscle quality (6,7). Cadaver studies demonstrate that these methods provide an estimate of muscle cross-sectional area that is